Organic Division
June Cumulative Examination

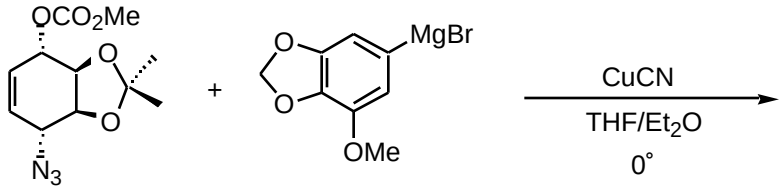
June 14, 1997
9:00 am Chemistry Reading Room

Chemistry, Stereochemistry, & Spectroscopy

1. Using the spectral information provided in Appendix 1, elucidate the structure of these common organic compounds. (5 points each). Make sure you show all your work so partial credit can be given for your reasoning.

A. see spectral data for benzyl alcohol
B. see spectral data for diethyl malonate
C. see spectral data for trans-2-butenal

2. A. The reaction shown below is an example of an *anti* - S_N2' substitution reaction. The spectral data for the product of the following reaction is given below and in Appendix 2. Using your chemical knowledge and the data given, provide a structure for the product. Make sure you show the correct stereochemistry. **Hint**: The large *J* values for the protons at 4.16, 3.36 and 3.10ppm tell you something about the stereochemistry. (10 points).



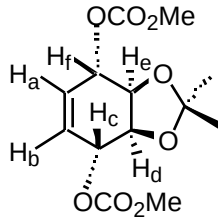
^{1}H-NMR (300 MHz, $CDCl_3$) δ 6.41 (s, 1H), 6.38 (s, 1H), 6.02 (ddd, *J* = 9.9, 3.9, 2.8 Hz, 1H), 5.98 (s, 2H), 5.87 (d, *J* = 10.0 Hz, 1H), 4.66 (appt, *J* = 5.0 Hz, 1H), 4.16 (dd, *J* = 9.6, 6.3 Hz, 1H), 3.91 (s, 3H), 3.36 (appt, *J* = 10.0 Hz, 1H), 3.10 (dm, *J* = 11.8 Hz, 1H), 1.57 (s, 3H), 1.44 (s, 3H); ^{13}C-NMR (75 MHz, $CDCl_3$) δ 149.2, 143.7, 134.9, 123.9, 110.1, 107.9, 102.1, 101.5, 78.10, 71.84, 67.36, 56.75, 46.65, 28.34, 25.77; IR ($CDCl_3$) 2989, 2935, 2887, 2112, 1632, 1513, 1454, 1218, 1061 cm^{-1}.; $[\alpha]_D^{20}$ -9.68˚ (c = 2.15, CH_2Cl_2); MS(EI) calcd for $C_{17}H_{19}N_3O_5$; 345.1326. Found; 345.1326, 345.13(100), 230.08(49).

see supplemantal material for JACS **1995**, *117*, 10143

B. Assign the ^{1}H-NMR and ^{13}C-NMR resonance's to the correct protons and carbons in your structure from part A. You may use your tables to help you with the chemical shifts. In the ^{13}C-NMR carbons with similar chemical shifts do not need to be identified specifically but you should assign them to the correct region. (15 points).

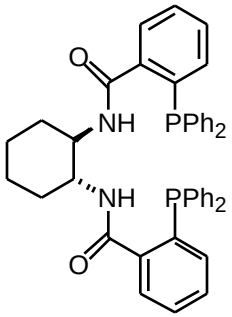
C. Assign the characteristic IR stretching frequencies to your structure. (5 points)

3. Consider the following molecule **A**:

A = 

A. What is the stereochemical relationship between H_a & H_b; H_c & H_f; H_e & H_d, the carbonate groups and the acetonide methyl groups? What is the consequence of these stereochemical relationships in the ^{1}H-NMR spectrum of this compound. (10 points)

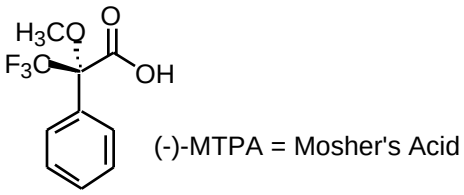
B. Suppose we react **A** with TMS-N_3 (trimethylsilylazide) in the presence of [π-allylPdCl]$_2$ and a chiral ligand. The chiral ligand **B** is known to promote the ionization and substitution of the *Pro-R* carbonate of **A** leading to a substitution product **C**. Show the product **C** of this reaction and assign the correct stereochemistry of each chiral center in **C**. (10 points)

B = 

C. Draw and assign the stereochemistry of product **D** that results from ionization and substitution of the *Pro-S* carbonate. What is the stereochemical relationship between the products **C** & **D** and can we distinguish between the two with ^{1}H-NMR or ^{13}C-NMR in a achiral solvent? (5 points)

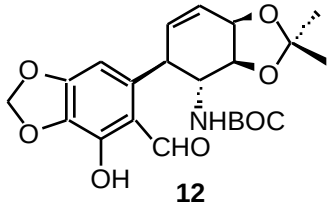
4. Assume you have synthesized a new chiral ligand for the reaction in 3B and you want to determine the extent of asymmetric induction in this reaction with your new ligand.

A. Suppose you make a chemical derivative of **C** using Mosher's acid (shown below). Draw the structure of your Mosher's acid derivative and discuss how NMR can now be used to determine the enantiomeric excess of the allylic substitution reaction. Be complete and make sure you include the necessary control experiments. (15 points)



(-)-MTPA = Mosher's Acid

5. Starting with compound **12**, What is the **final** product of the following set of synthetic transformations. Use the ^{1}H-NMR and ^{13}C-NMR data provided in Appendix 3 to help you determine the structure of the final product. Assign the characteristic resonance's that you used to arrive at the final product. You do not have to assign every peak, just indicate the ones that are characteristic to your final product.(15 points) **Hint**: Look for peaks that disappear from the starting material spectra and use the new peaks in the product spectra to help you fill in the blanks along the way to the final product.



12

BnBr, K_2CO_3, DMF → [ ]

[ ] → $NaClO_4$, KH_2PO_4; 2-methyl-2-butene, *t*-BuOH, H_2O

[ ] → CH_2N_2 → [ ]

[ ] → 1. HOAc, THF, H_2O, 60°; 2. *t*-BuOOH, $VO(acac)_2$, C_6H_6, 60° → Final Product see spectrum in Appendix 3

see supplemantal material for JACS **1995**, *117*, 3643